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GEOGRAPHIC SUPPORT PROJECT

# UTILIZATION OF KEYHOLE COVERAGE OF THE SOVIET RAIL NETWORK IN ICBM ESTIMATES



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## Foreword

KEYHOLE photography constitutes a major source of information on Soviet ICBM deployment, obviously facilitating the identification of deployed complexes. Equally important because of the extent, frequency, and quality of the photography, it also makes possible estimates as to what portion of the universe of knowledge about the deployment of ICBM complexes is lacking at a given point in time. With such estimates in hand and with the knowledge of what exists in areas covered by good photography, it is then possible to infer what is likely to exist in areas which are not covered.

For some time, statistical and cartographic information on the extent, timing, and location of effective KEYHOLE photographic coverage of the USSR has been utilized in the preparation of contributions by the Office of Research and Reports (ORR) to National Intelligence Estimates concerned with Soviet ICBM deployment. Estimates of the extent of usable photographic coverage together with assessments of construction schedules for various types of Soviet ICBM complexes are employed to arrive at a statistical appreciation of the number of ICBM complexes which are likely to exist in areas of the USSR where usable coverage is not available. This report explains the methods and criteria involved in deriving estimates of the extent of usable photographic coverage. It also presents estimates of this coverage by mission through Mission 9047 (5-9 November 1962) as well as the applicability of the coverage to various types of ICBM complexes.

Although ORR measures the amount of usable coverage and prepares the statistical appreciation with respect to the number of as-yet-unidentified ICBM complexes, the National Photographic Interpretation Center (NPIC) makes the basic interpretation of photography to determine the locations in the USSR which are covered by usable photography.

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Map

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# UTILIZATION OF KEYHOLE COVERAGE OF THE SOVIET RAIL NETWORK IN ICBM ESTIMATES


## Summary

KEYHOLE photographic missions covering the contiguous broad-gauge rail network of the USSR have made possible the determination, with varying degrees of confidence, of the presence or absence of typical patterns of ICBM complexes in the areas covered. Inasmuch as all known Soviet ICBM complexes are rail served, available KEYHOLE coverage of the Soviet rail network is examined, and those portions covered by photography judged to be of sufficient quality to reveal the presence or absence of the typical pattern formed by Soviet ICBM complexes are considered to be effectively covered and are plotted on maps. In instances of overlapping coverage, where more than one KEYHOLE mission covers a rail sector, only the latest mission is plotted. The non-overlapping route mileage covered by each of the KEYHOLE missions is then measured from these maps and is added cumulatively, from the most recent coverage to the oldest, to determine the percent of the Soviet rail network covered by photography since any specific date in the past.

The resulting cumulative data are correlated with cycles of construction at known Soviet ICBM complexes. To compensate for the gaps in photographic coverage, random distribution of complexes along the rail network is assumed, and probability theory can be applied to estimate the most likely number of complexes begun in the unobserved portion of the network.

This method for statistically assessing the number of ICBM complexes in areas where KEYHOLE coverage is either nonexistent or too old to show recent construction is an important, although not the only, basis on which the judgment respecting the total number of complexes is made.

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I. Definition of Effective KEYHOLE Coverage

In general terms, "effective" KEYHOLE coverage of the Soviet rail network is defined as photographic coverage of sufficient quality to reveal the presence or absence of the typical pattern formed by Soviet ICBM launch complexes. For purposes of compiling statistics on effective coverage, specific guidelines are used. All contiguous* broad-gauge rail route mileage is considered to be effectively covered by KEYHOLE photography if the portion of line visible on the photography is more than 8 nautical miles (nm) long and

(1) if the photography is cloud free to a distance of 15 nm on each side of the line and of sufficient quality to enable the detection of the distinctive pattern of support area, roads, and at least one launch area;

or (2) if clouds within the 30-nm belt are not extensive or dense enough to conceal road patterns or other identifying characteristics;

or (3) if clear photography extends to a distance of less than 15 nm on each side of the track, but no spurs or highways capable of supporting ICBM deployment are seen leading away from the main track into the obscured area.

No rail line is considered to be effectively covered unless the belt of clear coverage extends for more than 3 nm on each side of the track.

II. Preparation of Cartographic and Statistical Information on Effective Coverage

NPIC searches all the Soviet rail lines that appear on KEYHOLE photography and plots those which in their judgment meet the criteria stated above on a series of overlays of USAF World Aeronautical Charts (WAC). The rail lines so plotted are categorized according to KEYHOLE mission. If a line has been covered by two or more missions, the coverage is attributed to the most recent mission.** The amount of mileage*** covered by each mission is then measured from these overlays.

* Excluding a small amount of broad-gauge mileage that is not connected to the main rail network.

** For the geographic distribution of the coverage, see the accompanying map (inside back cover).

*** All mileage figures are statute miles unless otherwise indicated.

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To determine the extent of the total effective KEYHOLE coverage of the Soviet rail network since a specific date in the past, the total mileage of the most recent KEYHOLE mission is taken as a starting point. To this total is added that part of the mileage (termed net mileage) of each previous mission which has not been subsequently covered by a later mission. The net mileage effectively covered by each mission then is converted to a percentage of the total contiguous broad-gauge rail network in the USSR. By adding the percentages of net coverage, mission by mission, from the most recent to the oldest, it is possible to determine what percent of the Soviet rail network has been covered by effective photography since any specified date in the past.

The effective KEYHOLE coverage of the Soviet rail network is shown in Table 1.* The most recent mission given in this table is [redacted] 25X1 25X1, a mission that effectively covered a total of 20,817 miles, or 25.2 percent of the total contiguous broad-gauge rail network in the USSR. All the mileage of this mission is considered to be net mileage. An earlier mission, [redacted] 25X1 originally provided 11,920 miles of effective coverage. After the conclusion of [redacted] 25X1 however, only 615 of the miles originally covered by the earlier [redacted] 25X1 still remained uncovered by any later mission. Thus the net mileage of [redacted] 25X1 is only 615 miles, 0.8 percent of the total Soviet rail network. As of [redacted] 25X1 on a cumulative basis, 94.1 percent of the contiguous Soviet rail network had been effectively covered by KEYHOLE photography.

## III. Timing of Construction at ICBM Complexes on the Basis of KEYHOLE Coverage

The basic pattern of Soviet ICBM complexes consists of an extensive rail-served main support base that is connected to one or more launch areas by rail or by road. As much as 25 miles may separate the most distant launch areas in a single complex, with the distance between the main support base and the nearest launch area varying from 5 to 20 miles. The main support base is constructed first, but the ICBM complex is not recognizable as such on KEYHOLE photography until after the first launch area has been begun and the characteristic pattern of support base, road, and launch area has been created. Such a pattern appears in approximately the 8th or 13th month of the construction cycle of the ICBM complex, depending on which type of deployment system (DS) the first launch area represents.

* Table 1 follows on p. 4.

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Table 1

Effective KEYHOLE Coverage of the Soviet Rail Network

| Date of Mission (1) | Mission Number (2) | Net Route Miles Covered (3) | Percent of Total Network Covered Net (4) | Cumulative (5) |
|---|---|---|---|---|
| 1962 | | | | |
| 5-9 Nov | 9047 | 20,817 | 25.2 | 25.2 |
| 30 Sep - 2 Oct | 9045 | 8,904 | 10.8 | 36.0 |
| 18-19 Sep | 9043 | 1,236 | 1.5 | 37.5 |
| 29 Aug - 2 Sep | 9044 | 11,121 | 13.5 | 51.0 |
| 2-6 Aug | 9041 | 5,620 | 6.8 | 57.8 |
| 28-31 Jul | 9040 | 5,959 | 7.2 | 65.0 |
| 21 Jul | 9039 | 1,078 | 1.3 | 66.3 |
| 28 Jun - 2 Jul | 9038 | 6,633 | 8.1 | 74.4 |
| 23-26 Jun | 9037 | 4,150 | 5.0 | 79.4 |
| 30 May - 2 Jun | 9035 | 2,647 | 3.2 | 82.6 |
| 18-20 Apr | 9032 | 5,144 | 6.2 | 88.8 |
| 27 Feb - 3 Mar | 9031 | 1,437 | 1.8 | 90.6 |
| 1961 | | | | |
| 12-16 Dec | 9029 | 781 | 0.9 | 91.5 |
| 16-17 Nov | 9028 | 127 | 0.2 | 91.7 |
| 13-14 Oct | 9025 | -- | -- | -- |
| 12-14 Sep | 9022 | 219 | 0.3 | 92.0 |
| 30 Aug - 1 Sep | 9023 | 376 | 0.4 | 92.4 |
| 8-9 Jul | 9019 | 615 | 0.8 | 93.2 |
| 17-19 Jun | 9017 | 531 | 0.6 | 93.8 |
| 1960 | | | | |
| 8-10 Dec | 9013 | 101 | 0.1 | 93.9 |
| 18 Aug | 9009 | 180 | 0.2 | 94.1 |
| TOTAL | | 77,676 | 94.1 | |

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Through the analysis of KEYHOLE photography, four deployment systems have been distinguished, and, on the basis of repeated coverage, differences in timing of the construction of these systems have been established. Table 2* gives the variations in the timing of construction for three of the systems. The DS-I system, which became operational in 1960, is no longer being built. ICBM complexes may include more than one type of deployment system. For estimative purposes the complexes are categorized under the construction cycle of the deployment system represented by the first launch area.

* Table 2 follows on p. 6.

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Table 2

Timing of Construction at Soviet ICBM Complexes

| Type of Complex | Month of Construction at Complex: First Launch Area Begun | Identifiable Pattern Appears | First Launch Area Operational |
|---|---|---|---|
| Soft | | | |
| Deployment System II (DS-II) 1/ | 7th | 8th | 19th |
| Deployment System IV (DS-IV) 2/ | 7th | 8th | 17th |
| Hard | | | |
| Deployment System III (DS-III) 3/ | 7th | 13th | 27th |

1. Soft, road-served launch areas for the SS-7 ICBM.
2. A new type of soft, road-served launch area, first observed in early 1962, probably for the SS-8 ICBM.
3. Hard, road-served launch area, probably silo type, for the SS-7 ICBM.

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IV. Correlation of Cumulative Coverage and ICBM Construction Timing

Tables 3, 4, and 5* show how cumulative percentages of coverage are correlated with construction cycles at DS-II, DS-III, and DS-IV types of ICBM complexes, respectively. These tables indicate the amount of coverage on which complexes started during a specified time period would be detectable. In similar manner the amount of coverage that would show complexes becoming operational at the first launch area during a given time period can also be read from the tables. Thus it is possible to determine from these tables the extent to which the Soviet rail network has been inspected relative to complexes of a given type and age.

The following examples from Table 3 illustrate the information that can be read from the tables. Ninety per cent (see line 8) of the Soviet rail network has been inspected for DS-II complexes initiated in June-July 1961. The presence or absence of DS-II complexes initiated during December of 1961 (see line 4) is detectable along 66.3 per cent of the Soviet rail network. There is no coverage that would show ICBM complexes of the DS-II type started after April 1962 (see line 1), for any such complexes would not have reached a recognizable stage of construction at the time of [redacted] (November 1962). The presence or absence of DS-II complexes becoming operational at the first launch area by December 1962 would be detectable along 90 per cent of the rail network (see line 8). 25X1

With the amount of coverage that would show complexes initiated during a given period and with the number of complexes known from this coverage to have been started, an estimate of the number of complexes started along the unobserved portion of the rail network during the same period can be made by assuming random distribution and by applying probability theory to calculate the most likely number of complexes in the unobserved area.

* Tables 3, 4, and 5 follow on pages 8, 9, and 10, respectively below.

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Table 3

Correlation of Construction Timing at DS-II ICBM Complexes
and
Effective KEYHOLE Coverage of the Soviet Rail Network

| (Line) | Date of start of construction 1/ | Date operational at first launch area | Percent of rail network along which complexes would be recognizable |
|---|---|---|---|
| 1 | Mar-Apr 62 | Sep-Oct 63 | 25.2 |
| 2 | Feb 62 | Aug 63 | 37.5 |
| 3 | Jan 62 | Jul 63 | 57.8 |
| 4 | Dec 61 | Jun 63 | 66.3 |
| 5 | Nov 61 | May 63 | 79.4 |
| 6 | Oct 61 | Apr 63 | 82.6 |
| 7 | Aug-Sep 61 | Feb-Mar 63 | 88.8 |
| 8 | Jun-Jul 61 | Dec 62 - Jan 63 | 90.6 |
| 9 | May 61 | Nov 62 | 91.5 |
| 10 | Mar-Apr 61 | Sep-Oct 62 | 91.7 |
| 11 | Feb 61 | Aug 62 | 92.0 |
| 12 | Jan 61 | Jul 62 | 92.4 |
| 13 | Dec 60 | Jun 62 | 93.2 |
| 14 | Jun-Nov 60 | Dec 61 - May 62 | 93.8 |
| 15 | Feb-May 60 | Aug-Nov 61 | 93.9 |
| 16 | before Feb 60 | before Aug 61 | 94.1 |

1. The months shown in the table were established in the following manner. Each month containing one or more missions was taken as the month of the construction cycle in which an identifiable pattern appears, according to Table 2. The cycle for the DS-II deployment system was then projected back to show the month or months in which a complex newly recognizable on the mission was started and forward to show the month or months in which the first launch area of such a complex becomes operational.

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Table 4

Correlation of Construction Timing at DS-III ICBM Complexes
and
Effective KEYHOLE Coverage of the Soviet Rail Network

| (Line) | Date of start of construction 1/ | Date operational at first launch area | Percent of rail network along which complexes would be recognizable |
|---|---|---|---|
| 1 | Oct-Nov 61 | Dec 63 - Jan 64 | 25.2 |
| 2 | Sep 61 | Nov 63 | 37.5 |
| 3 | Aug 61 | Oct 63 | 57.8 |
| 4 | Jul 61 | Sep 63 | 66.3 |
| 5 | Jun 61 | Aug 63 | 79.4 |
| 6 | May 61 | Jul 63 | 82.6 |
| 7 | Mar-Apr 61 | May-Jun 63 | 88.8 |
| 8 | Jan-Feb 61 | Mar-Apr 63 | 90.6 |
| 9 | Dec 60 | Feb 63 | 91.5 |
| 10 | Oct-Nov 60 | Dec 62 - Jan 63 | 91.7 |
| 11 | Sep 60 | Nov 62 | 92.0 |
| 12 | Aug 60 | Oct 62 | 92.4 |
| 13 | Jul 60 | Sep 62 | 93.2 |
| 14 | Jan-Jun 60 | Mar-Aug 62 | 93.8 |
| 15 | Sep-Dec 59 | Nov 61 - Feb 62 | 93.9 |
| 16 | before Sep 59 | before Nov 61 | 94.1 |

1. The months shown in the table were established in the following manner. Each month containing one or more missions was taken as the month of the construction cycle in which an identifiable pattern appears, according to Table 2. The cycle for the DS-III system was then projected back to show the month or months in which a complex newly recognizable on the mission was started and forward to show the month or months in which the first launch area of such a complex becomes operational.

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Table 5

Correlation of Construction Timing at DS-IV ICBM Complexes
and
Effective KEYHOLE Coverage of the Soviet Rail Network

| (Line) | Date of start of construction 1/ | Date operational at first launch area | Percent of rail network along which complexes would be recognizable |
|---|---|---|---|
| 1 | Mar-Apr 62 | Jul-Aug 63 | 25.2 |
| 2 | Feb 62 | Jun 63 | 37.5 |
| 3 | Jan 62 | May 64 | 57.8 |
| 4 | Dec 61 | Apr 63 | 66.3 |
| 5 | Nov 61 | Mar 63 | 79.4 |
| 6 | Oct 61 | Feb 63 | 82.6 |
| 7 | Aug-Sep 61 | Dec 62 - Jan 63 | 88.8 |
| 8 | Jun-Jul 61 | Oct-Nov 62 | 90.6 |
| 9 | May 61 | Sep 62 | 91.5 |
| 10 | Mar-Apr 61 | Jul-Aug 62 | 91.7 |
| 11 | Feb 61 | Jun 62 | 92.0 |
| 12 | Jan 61 | May 62 | 92.4 |
| 13 | Dec 60 | Apr 62 | 93.2 |
| 14 | Jun-Nov 60 | Oct 61 - Mar 62 | 93.8 |
| 15 | Feb-May 60 | Jun-Sep 61 | 93.9 |
| 16 | before Feb 60 | before Jun 61 | 94.1 |

1. The months shown in the table were established in the following manner. Each month containing one or more missions was taken as the month of the construction cycle in which an identifiable pattern appears, according to Table 2. The cycle for the DS-IV system was then projected back to show the month or months in which a complex newly recognizable on the mission was started and forward to show the month or months in which the first launch area of such a complex becomes operational.

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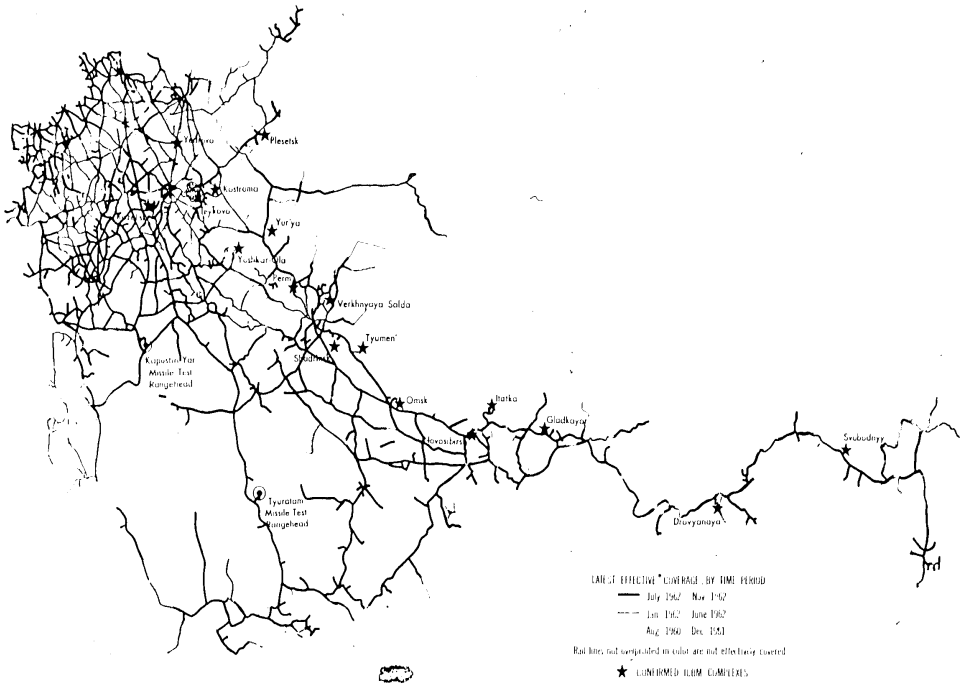
EFFECTIVE* KEYHOLE COVERAGE OF THE SOVIET RAIL NETWORK

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